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THESIS

The Role of Monopolistic Business in Regard to Technological Development and Research

by

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Chapter I INTRODUCTION

Over the years much has been written about the many aspects of monopoly. In this work the approach to the problem is made from three directions which are:

First, an appraisal is made of the way our patent system affects technological development under competitive and under monopolistic conditions.

Second, a comparison is made of the various types of research as carried on today by large corporations, by universities and by individuals.

The third approach brings out some of the ways in which monopoly interests have perverted their research in such a manner that it acts as a brake on progress rather than an aid to public welfare.

Chapter II

FOUNDATIONS OF TECHNOLOGICAL DEVELOPMENT

A. Industrial Growth Under Competitive Conditions

1. The existence of patent laws giving inventors a legal monopoly for a 17 year period during which time the invention or new method may be exploited by owners alone, serves as an incentive to individuals and industrial concerns to undertake expensive research, for the owners know that any fruits of the research can be protected. If such protection were not afforded by law, less extensive research would be done due to the fact that valuable individual findings would in short order be adopted by all competitors. In this case the cost of the research could not be charged against the new technique.

As an example of research under the incentive of the patent laws there follows a brief history of the growth of television as described by Philo Farnsworth, of Farnsworth Television Co. before the TNEC hearings. (1) While still in high school in 1922, Mr. Farnsworth made his first great invention, a means of producing an electric counterpart of an optical image, thus allowing television images to be accomplished without moving parts. From this small beginning the research on the subject was continued and gradually financial backers were recruited, their investments made not with the hope of immediate return but on the later expectation of in-

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(1) Temporary National Economic Committee 76th Congress, 1st Session, Part 2, Patents, Pages 981-1002.

come on the perfected technique protected by patents. On this basis the original backers plus others had put up over a million dollars by 1940. It is thus seen that the research beyond the bare original stage could not have been continued without the protection of the patents on the inventions which gave the financial backers security, not, of course, of the ultimate success of the new development, but of protection from the exploitation of the technique, if successful, by other companies.

2. Although the patent laws can serve as an incentive to progress as the case of the Farnsworth Company indicates, a complete and unrestrained freedom in the development of new techniques would in itself be a fallacy. Under competitive conditions if new machines were installed only to be replaced in a month by other, slightly more efficient machines, chaos would be the result. One reason for the purchase of new machinery and equipment is to gain the extra income which will accrue to the owner of this new installation above that gotten by competitors who are using older, less efficient means of production. Alfred Marshall has expressed this idea in his discussion of quasi-rent, by which he distinguished the temporary surplus of income gotten by the use of various man-made devices of production put to use before adoption by a competitor or put to better use than by a competitor.

If there were a continuous replacement of new

machines for slightly outmoded equipment, an owner could get no return from the use of a machine before it was replaced by a new type, which in turn would be replaced by a further improved model. Rather, installations and equipment must be used for a reasonable time so that the cost of the equipment can be amortized over a period of years and a depreciation fund built up with which eventually to supplant the machine when its useful life is past. It is on this basis, except in unusual circumstances, that business makes changes in capital installations by a gradual replacement of units as their usefulness is ended. Consider the railroad industry. In the '30s it became apparent that the lightweight streamlined train was the newest development, but it would have been impossible for the railroads to have scrapped all their rolling stock for the new models, even if their financial condition had been good. Rather by gradual replacement of the old coaches and engines with the new equipment, the railroads have changed their lines over to the more modern trains of today.

This condition holds true in all fields, for some of course, the interval needed for change beingshorter and for others longer due to the capital invested and to such other factors as style considerations and competitors' actions. However, under the pressure of war with its abnormal demands, industries through government subsidies and extra profits may make many changes in equipment and make them at

more frequent intervals, which changes they would have spaced over a much greater period of time if normal conditions had existed. This is a reason for the great technical strides made in methods of production in certain industries during war times which when carried over to normal periods, result in an over-expanded capacity in relation to the post war civilian market.

B. Industrial Growth Under Monopolistic Conditions

1. Just as patent rights may be an incentive to research under competitive conditions, so they may be used as restrictive devices under monopoly conditions. In a highly competitive industry the use of a patented article will spread throughout the entire industry as rapidly as the patent laws will permit. Each firm will make use of any improvements it has perfected as soon as it can to try to get ahead of competitors. So although production of the original patented device is monopolized in the firm holding the patent, competitive firms often perfect other articles for similar use which they in turn patent. The end result is that the first article, despite the patent, meets stiff competition from other patented articles able to serve a similar purpose.

However, when an industry is dominated by one firm the situation is altered. Here a patent is often bought up not for the purpose of using it, but rather of suppressing its use. Such action will keep a new business from using the patented device and thus to prevent the growth of competition. Another reason for the monopolist's not using the patent

is in order not to change his methods which are highly profitable as they are.

The purpose of the patent system is to encourage the discovery of new devices, or improvements on existing ones as we have seen; yet it might be to the advantage of the country as a whole for the government to buy outright certain specific patents which affect the national welfare and then allow production by all who were interested thereby causing large and complete distribution of the article under competitive conditions. Such an action on the part of the government would end the undesirable condition of industries' buying up patents on methods the use of which would benefit the entire country, whereas the suppression by the monopolists allows no benefits to accrue to the people, only to the monopolist. Also, to make the patent right contigent on its actual use, or suffer forfeiture as a consequence of non use, would go far to alleviate this condition and force the utilization of the patent.

Other means by which patents are used to restrict progress and thus choke competition are:

(a) Patent Fencing - by means of this method, inventors of competitive techniques are restrained from making effective use of their invention, thus hindering rather than promoting progress. Fencing of patents requires a thorough study of the competing device or technique, surrounding it with numerous patented inventions, and forseeing all possible principles by which improvements could be made and patenting them,

making it impossible for the owner to exploit his invention without being involved in a patent infringement suit. (1)

(b) Patent Litigation - this is a method of using the patent system to benefit monopolistic elements. Recourse to courts of law is allowed on the theory that an inventor has the right of legal protection for his patent right. Often, however, this purpose has been perverted in such a manner that the court becomes a means of intimidating rather than aiding the inventor. Using the courts for such ends, large combinations may force an inventor to defend his rights in many court circuits at once, with suits settled in the inventor's favor, being appealed to higher courts, piling up costs which but few individuals can afford. By such means, a holder of a patent right, having been bled by the court costs defending his rights, may be forced to submit to the terms of the combination fighting him, however unsatisfactory these terms may be.

(c) Patent Interference - is used officially by the Patent Office to determine which of two applicants for a patent is entitled to it. However, monopoly interests use this device for other reasons. By applying for patent rights on similar devices, they seek to delay the development of processes which might lead to competition. (2)

These are illustrations of the more important

(1) Hearings Before TNEC, P.2, pages 381-384; 449-450.
(2) Ibid.

means by which the patent system may be used to protect not the individual inventor but to protect the interests of industrial combinations by giving the large interest various levers to outwit the holder of a patent right or force his capitulation.

2. Monopoly of itself may result in industrial over-development which result is rather contrary to the desires of the monopolist. Where free entry into a field is possible, the one or few manufacturers are constantly being crowded by new producers who enter to reap some of the profits. However, as other concerns drift into the circle, the existing equilibrium is upset causing an end result which does not benefit either consumer or entrepreneur. With more producers present, each owner finds that operations are less profitable since each has less of the market for his goods. To overcome this condition, competitive selling may be used which however may easily increase costs and prices and thus further reduce sales and so continuing the cycle, increasing supply will be attended by increasing instead of decreasing prices and falling rather than rising sales. (1)

If there occurs a sudden increase in demand for a commodity produced by a monopoly or under oligopolistic conditions, a great surplus of productive capacity is likely to grow up, especially if time is needed to build new plants. Where demand at first exceeds supply, there arises speculative purchasing with buyers ordering more than is needed for present

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(1) Schumpeter, "Capitalism, Socialism & Democracy", Chapt. VII Page 85.

consumption which in turn makes the supply shorter and this in turn draws in more producers. When eventually the new plants begin operation, it is found that the total capacity now far exceeds the total demand. This development causes the monopolist to adopt new methods to cut costs and further increase output which action will result in an even worse predicament. As an end result neither producer nor consumer will gain from the overexpanded capacity. A discussion of the nitrogen industry follows which develops this point more fully.

(a) The Nitrogen Industry as an example of overdevelopment.

For hundreds of years the nitrogen industry was almost entirely confined to collecting and spreading manure, the prime source of nitrogen. By the middle of the 19th century, a shortage began to develop; the productivity of the earth began to decline because the growing population was not able to put back into the soil as much nitrogen as it took out.

At this stage began the exploitation of the vast deposits of sodium nitrate found in the Peruvian and Bolivian deserts. Here was a natural monopoly of the needed product. In 1879, Chile which had invested heavily in the nitrate fields of Peru and Bolivia, declared war on these countries and wrested from them control of the nitrate fields. Further exploitation was now carried out and by 1912, thirty five companies mostly foreign, were engaged in the extremely profit-

able business of mining sodium nitrate.

With the coming of World War I, these fields as basic supplies for munitions, took on an even more important role. So great was the war demand for nitrates, that Chilean interests in 1916 sold some 3,300,000 tons of the nitrate in New York at a price of $77.62 a ton. Of this, approximately half went to the producers.

This profitableness of the business and the pressure of the war, both resulted in great technological strides in other countries in the production of nitrogen. Techniques were developed of extracting the product from the air and as a by product of other processes.

While these new nitrate plants were in their infancy, the costliness of the process made government subsidization necessary. In the eleven year period from 1923 through 1934, as a result of the great industrial growth in the nitrate field stemming out of the monopoly control of the product, world capacity increased three and one half times to an equivalent of 5,082,000 tons of nitrogen annually. Most of the increase was accounted for by new synthetic plants built in various countries of Europe.

In the United States, the nitrogen industry was practically created in 1926 and 1928, not by government subsidy, but by two large chemical companies. These companies were Allied Chemical and Dye Company and DuPont, which felt that they could extract the nitrogen of the air more cheaply

than Chilean interests could mine the nitrates.

In the middle of the 1920's the cost of Chilean sodium nitrate was $22.50 a ton delivered plus the Chilean government tax of $12 a ton resulting in a final price of approximately $35 a ton in New York. Allied Chemical and DuPont by means of their new processes, planned to beat this cost figure by a large margin. DuPont began operation in 1926 of a plant in West Virginia with an annual capacity of 180,000 tons of nitrogen. By 1928, Allied Chemical had its plant in Virginia in operation, this plant with a capacity of 200,000 tons of nitrogen.

At the same time these companies were growing, other companies were being developed in this country such as Mathieson Alkali, Hercules Powder, Military Chemicals, Lion Oil and Commercial Solvents. Whereas DuPont and Allied Chemical once had 85% of the United States nitrogen capacity, as these newer companies became established, this figure dropped to but 55%. During the World War II period, total United States nitrogen producing capacity was stepped up from 590,000 tons annually in 1939 to 1,322,000 tons in 1944.

The end result of this greatly increased world capacity to produce nitrogen was a period of violent price competition between the various companies and countries, with prices falling from the New York price of $77.62 a ton in 1916 to $18 a ton in 1932. However, of more interest is

the general picture given of the tremendous growth and technological development growing out of the original nitrogen monopoly position held by Chile. (1) The end result of this great increase in world capacity and lowered prices was that none of the companies made money and actually Allied Chemical and DuPont subsidized their continued production out of profits on other of their products.

3. Technological development of itself leads to a concentration of economic power. Certain advantages make for greater efficiency under conditions of large scale operations which tend toward this concentration of power. These advantages are:

(a) a smaller capital outlay required for a given capacity.

(b) greater mechanical efficiency achieved since a machine with twice the capacity of a smaller one does not use twice as much fuel or occupy double the space.

(c) less labor needed per unit of capacity.

(d) lower transportation costs gotten by carload lots.

(e) costs cut by the use of special tools and devices which could not be employed in small scale plant. (2)

Certain types of manufacturing operations lend

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(1) Fortune - February 1944.

(2) National Research Project, "Effects of Current and Prospective Technological Developments on Capital Formation" by David Weintraub, Page 5.

themselves to the use of large scale methods. Representative of this class are the continuous process industries such as steel, chemical, cement and flour. By using special equipment developed through experiment and adapted exclusively to the tasks in the industry, a large output capacity has been created and a low unit cost assured at optimum production. Such equipment necessitates large capital investment, which high cost in turn results in economic concentration to control output and maximize use of the machinery.

As an example of a furtherance of economic concentration as a result of technological development, the steel industry will serve well. In the steel industry, the automatic strip mill represents the most efficient type of rolling technique. The saving in labor costs by use of the process has been tremendous. 126 men in a strip mill can produce the same tonnage per a given period of time, as 4512 men in a hand mill, a 97% reduction in man hours. (1)

Smaller companies operating obsolete hand mills cannot afford to install the equipment necessary in a strip mill. As a result, these small mills are daily losing business to the strip mill producers whose costs of production are far below that of the hand mills. The economic effect therefore is the elimination of the hand mills and a further concentration of producing facilities in the smaller number

(1) T.N.E.C. Monograph #22, Technology in Our Economy.

of large strip mills. Thus the new technology in steel, though giving increased production ~~redocution~~, results in this production coming from but a few producers. (1)

In the brick and tile industry also certain large scale techniques have caused a concentration of production in a few firms. One of these developments is the autobrick machine, which mechanically sands the mold, disposes of excess clay, and jars the mold to loosen the formed clay, reducing labor requirements some 50%. (2) The installation of these machines was principally made in the large plants due to the high cost of the equipment which the smaller companies could not afford.

Other examples of industries could be cited in which greater efficiency of large scale equipment has led to a concentration of power because of the excessive cost to the small manufacturer of capital outlay for equipment.

4. Influences Toward Restriction of Technological Development

(a) Petroleum Industry and Pipe Line Control

That the major integrated petroleum companies control the market for their products is in large measure due to their control of the crude oil and gasoline pipe lines. (3)

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(1) T.N.E.C. Monograph #22, Technology in our Economy.
(2) National Research Project, "Productivity and Employment in Selected Industries, Brick and Tile", Miriam West.
(3) Petroleum Investigation, "Hearings on H. Res. 441, Washington 1934.

The ease or difficulty with which independents move their goods to market is a means of ascertaining the prescence or absence of competition within an industry. The degree of control in the oil industry is shown by the following figures. Of the crude oil pipeline mileage in this country, 89% is controlled by fourteen large integrated companies; gasoline pipelines are controlled to an even greater extent with 96% owned by the major oil companies. (1) Such conditions work to the detriment of the ind ependent refiners and producers and in so doing serve as a brake on further developmental and expansion work in the field. Especially discouraged by this means are new companies which desire to enter the oil fields, if these companies have new technologies of well digging or refining beyond that which the established concerns have in use.

Pipe lines are considered common carriers and as such subject to control by the Interstate Commerce Commission. However, such regulation has not been too effective nor has it afforded the independents any marked increase in the use of the pipe lines. The rates of the pipe lines are for the most part equivalent to those charged by the railroads for an equal amount of oil carried by tank cars. In this manner the integrated concerns owning the pipe lines charge themselves high rates, which charges are of course also

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(1) T.N.E.C. Hearings, Part 1, P. 14, P 7103, 7171, 7172.

levied upon all others who may use the facilities. (1)

The profits from these pipelines are large and are often used by the integrated companies to subsidize their refining plants and retail outlets. The independents of course have no such extra income to call on and the overcharges which they pay the pipeline owners for the use of their facilities are actually drawbacks interfering with their competitive position and act as a bar to expenditures on research or technological improvements in the field.

Others factors also add to the difficulty of the independents in their attempts to use the pipelines and these are: the absence of pipeline connections near the independent refineries; the fact that the lines are much of the time filled to capacity with the products of their owners; and also the existence of certain minimum requirements on amounts of oil to be transported which requirements are often at such levels that the smaller producer cannot meet them and must thus either sell locally or find other means of transport. (2) In many cases only one line serves a whole field forcing the independent to use the facilities at the established rates or sell the oil direct to his competitor, the owner of the pipeline. (3)

(1) F.T.C. Report on Pipeline Transportation of Petroleum, Wash., 1916.
(2) "Report on Pipelines", House Report 2192, Pt. 1, Wash. 1933.
(3) T.N.E.C. Hearings, Pt. 15, P8300.

With all the factors taken into consideration the end result seen is that the independents have but little profit left them after being forced to pay the very high pipeline rates. These smaller producers are thus not in a position to use funds for research or technological improvements. The integrated companies in control of the pipelines have the funds to carry on research, which, of course, they do to a certain extent. However, their position is not such as to require a constant scramble for better methods to outwit competitors as would be the case were the market and profits divided in a more equitable manner amongst the now integrated concerns and the struggling independent producers. To sum up, research is being carried on under the present conditions, but improvements in drilling and refining have not been forthcoming at as rapid a rate as would have been the case if competitive conditions had required it. Excluded from this picture must be the developments forced by the exigencies of the war and the present petroleum crisis.

5. Product Differentiation and Its Effect on The Entry of New Products Into the Market.

Whereas Section 4 indicated the problems of a small competitor in the petroleum industry, this section will show the problems encountered by a new firm trying to enter into competition with established firms. Here the newcomer is in a very difficult position as the following pages

indicate.

Differentiation of product may be due to certain characteristics inherent in the product itself or upon the basis of the patented features, trademarks or names, design or color of container, or to advertising. When the advantage of each sellers' location in regard to convenience to the customer is considered, it is apparent that although the products sold by different outlets may be physically identical, to the buyer there is a differentiation due to the very location of the seller. (1) It would be impossible to compare the value of the monopoly rights acquired under the patent and copyright laws with that gotten from trademarks, tradenames, and general goodwill. The main fact to be derived is that whatever the cause of the differentiation, the end result is that the customer will prefer one product to another as long as these distinguishing conditions continue to exist.

Whereas as above indicated, advertising is a partner to imperfect competitive conditions, to the layman on the other hand, advertising is the symbol of rigorous competition. Obviously there are varying degrees of product differentiation and this makes it difficult for the ordinary person to perceive the role advertising has in restraint and as a barrier to free entry into a market.

The owner of a product the price of which is determined competitively gains nothing from advertising.

(1) Chamberlin: "Theory of Monopolistic Competition" P.56.

Advertising has for its purpose the carving out or capturing of a certain portion of a market and in so doing establishing for the advertiser a monopolistic position.

Before the ascendancy of modern advertising, new products could be established on the market on the basis of the reputation of the manufacturer or seller for his quality goods and/or the price at which the new article was offered. Commodities of a less complex nature and less the product of technology and chemistry could formerly be weighed by the consumer in regard to the intrinsic worth of the item. However, the consumer goods and producers goods which the buyer himself can test before purchase have become fewer and fewer in number and the sales appeal has turned to the psychological approach with colorful advertisements, placards, and displays presenting and praising the product to the buyer, all these stemming from a well directed and formulated promotion scheme.

Under this new scheme of life, a new product must be presented to the public through the medium of some expensive and elaborate promotional devices. Less attention is paid to the real value of a product than to the needs of the advertising program when attempting to get a product before the public eye. This hurdle which a new product must negotiate is many times insurmountable and the very difficulty of entry to an established field closes the market in many cases to all but very well financed companies.

Improvement of products already on the market through research and further technological development is not enough to win a place. The following example will show the importance of advertising in getting a new product introduced on the market. The case is the experience of a toothpaste manufacturer as he reported his experiences to the Temporary National Economic Committee. (1)

In 1939 the retail market for toothpaste was controlled by ten companies which had gained their position by continual advertising of their various brands. An attempt was made by the new toothpaste manufacturer to gain a market for his product on the basis of value of product alone,without an advertising buildup.

The product itself was a good one, an improvement over the existing pastes on the market. The manufacturer had secured approval from the American Dental Association, which approval meant quite a bit since the association had approved only one toothpaste put out by the ten above mentioned companies. Another proof of the desirability of this product was indicated by the government's signing contracts for purchase of the toothpaste, showing that the paste had passed some stiff governmental tests. A third point in favor of the new toothpaste was its price, set a a level of half that charged for a similar package by the ten established companies. From these factors it is seen that if quality and price were the only necessary criteria to

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(1) T.N.E.C. Hearings, Part 8, P3396-3412.

sell a product, this new manufacturer should have encountered no trouble in selling the public.

However, the manufacturer related that his product had all necessary attributes for success but one. Lacking was a means of access to the consumer. The buying public had been segregated by the established manufacturers, not by physical means but by means of repetitious advertising, so that each of the concerns had a certain portion of the market as his own in just as definite a way as if the consumers had been arbitrarily allotted among the various companies. When the new manufacturer tried to interest retailers in stocking his product, he encountered a stone wall. The retailers agreed to the value of the product but refused to stock the item unless customer demand was previously built up.

A good product in itself is not enough to allow entry into such a controlled market. Another and more valuable type of product differentiation must be gotten by means of advertising. By this means a portion of the monopolized market can be acquired. On this basis the producer told how he found it necessary to try to buy his way into the consumer market. In consultation with several advertising agencies he was informed that a beginning survey costing $100,000 would be needed to discover whether an advertising program would meet with success. The actual

promotion program would have been much more costly. Such large expense serves to limit entry into a field and to act as a bar to increasing competition.

On this basis, actual technological improvement as incorporated in a new product, would do little to assure sales. Rather the more important factor would be the ability to finance a promotion program to win part of the market for a new product.

Although the experience of this manufacturer shows the difficulty of entry into a field despite research and actual improved product, one must not overlook the value of research for new products and for improving old products. That research plays an important role in many ways in furthering technological development is presented in the following chapter.

Chapter III

TECHNOLOGICAL DEVELOPMENT AND LARGE SCALE RESEARCH

Although research is being done in laboratories the country over, for the most part it is concentrated in fields which are quite fully developed and owned by monopolistic interests. By the use of patent pools the findings of pure research made in these centers are freely disseminated for use, but on matters closely related to the work of the company, research findings are closely guarded and wherever possible protected by patents. Under such circumstances the benefits to be derived from the research are slow to become widespread since the controlling interests which spent time and effort on the subject naturally desire protection and time to reap the benefits of the new development.

For the country to continue its economic and cultural advancement there is a need for new and unexploited fields to be opened which will serve as bases for further technological development. History has shown that what is called economic progress has come in spurts and with the present increasing research work we may well be on the threshold of another rapid development paralleling or exceeding that of the '20s. This chapter and the following two chapters are concerned with research in its various forms as carried on by monopolistic interests and by universities

and individuals.

A. Trends in Industrial Research

1. That industrial research is on the upswing is shown by the following studies. A survey of industrial research made in October of 1947 by the Evans Research and Development Corporation of New York revealed the following data on present and future industrial research patterns in the chemical, petroleum, paper, drug and food fields as well as for industry as a whole as shown by the answers to the questions asked. (1)

(a) What percentage of research time is devoted to -

	Chemical	Petroleum	Paper	Drug	Food	Total Average
Improvement of present products and processes	48.1	49.4	51.2	35.7	55.2	47.6
Development of new products, processes in own field	42.3	44.4	41.6	55.9	41.8	42.3

(b) Is the amount of money spent of research today -

Greater than prewar	88.6	91.1	84.0	88.7	85.8	87.1
Same as prewar	7.8	8.9	12.0	11.3	14.2	10.6
Less than prewar	3.6	0	4.0	0	0	2.3

(c) In the future, do you expect that research will be -

Increased	75.0	91.6	76.0	65.1	71.4	72.5
Decreased	.6	0	0	0	3.5	.6
No Change	24.4	8.4	24.0	34.9	25.1	26.9

(d) If an increase is planned, do you expect to -

Expand own facilities	61.1	81.8	57.1	60.7	51.3	60.0
Use independent lab	2.2	0	0	0	4.9	1.3
Do both	36.7	18.2	42.9	39.3	42.8	38.7

(1) Business Week, November 1, 1947

2. Another survey of a similar nature was carried out by the National Association of Manufacturers early this year. The findings of this survey entitled "Trends in Industrial Research and Patent Practices" were much the same as those of the Evans Corporation previously cited.

Results of the N.A.M. survey which encompassed 983 manufacturers, showed that of all the firms contacted, 74% said that they maintained their own research laboratories. Estimated total research expenditures for 1947 were $207,384,188, some $26,000,000 more than was spent in the preceding year.

The survey also showed that 57% of the manufacturers said they planned to expand their research facilities within the next two years. (This figure corresponds closely to the 60% figure for industry as a whole under part "d" of the Evans survey). Only 1% of the companies maintained basic or fundamental research; 56% described their programs as primarily for product improvement, with a large proportion describing their programs as looking for long term rather than immediate benefits.

The principal objective of 40% of the companies replying was improvement of existing products and an equal number reported new product development was their prime research objective. Many of the companies felt that the development of new products is of greater importance to the

long term growth of the company. (1)

B. Research at Republic Steel Corporation

Typical of steel research centers is Republic Steel Corporation's Process and Product Development Division. The work carried on in this laboratory falls under the following headings: planning, chemical analysis, test production, plating, and strength and stress testing.

This research division of Republic Steel was established ten years ago to perform a wide range of services for the company. Its staff of forty is housed on two floors of a Cleveland subsidiary. This unit is the potential core of a much larger research center for the giant steel corporation. However, as yet, the research division does not carry on all research work that is done by Republic as some is done by independent laboratories.

The work of the division is done for three classes of clients; the steel mills, subsidiary plants and for customers.

For the mills: a new product or an improved product is rarely developed which will use a standard steel in the same old way. By working with the processes, the research center is able to indicate the new method and to aid in making a smooth transition by the mill to this new technique. A constant research is carried on by the center for new uses for mill waste products as an aid in

(1) New York Times; January 26, 1948, N.A.M. Research Report.

cutting costs.

For Subsidiaries: the work of the center has resulted in the development of a host of new products with many of these not yet put on the market. Experiments have been made on steel panels used as sidewalls, floors, ceilings and even roofs for home construction.

Tests have been made on steel piping with a plastic inner coating to defeat corrosion. A boiler which formerly had to be retubed every year, has lasted four years with this new pipe installation.

For the customer: in this field,work of the development division is strictly limited to steel problems. A constant effort is made to avoid getting involved with customers' problems of design and the like. In the past, customers have come to the division with requests for the company to help them design entirely new products and for this reason Republic has been wary in its dealings with customers on research problems. (1)

C. Continuing Research Projects

A discussion follows of the research divisions of General Electric and General Motors. The research of these companies is representative of that carried on by such other firms as R.C.A., Bell Telephone, DuPont, Bakelite and Standard Oil to name only a few whose research

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(1) Business Week, November 15, 1947

divisions have long been active in their respective fields.

1. General Electric Research Laboratories

The laboratory which had its small beginnings 45 years ago in the work of Dr. Whitney of M.I.T. and his associates grew until it is a unit made up of some 300 people, 100 of whom are research workers, men who otherwise would be found in the university research centers. This laboratory is now devoted to unrestricted fundamental research, to try to establish new facts and principles in not only the Electrical field, but in all fields now that electrical properties are regarded to be the core of all matter.

Findings of the laboratory workers are published so that all the workers may know what every other member is doing and the results of all the research work which is of interest is made known to the general public as soon as patent application has been made on such data that is patentable. In line with this policy of non secrecy of findings is that of cooperation and discussion of work and problems with research workers in universities and even with those of competitors. (1)

With the end of the war came plans for expansion of research and development by General Electric. Announcement was made recently of the erection in Schenectady of a new laboratory costing some $8,000,000. The laboratory

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(1) T.N.E.C. Hearings, Part 3 Patents, Testimony Dr. William Coolidge, Director of G.E. Research Laboratories.

was built on a high elevation to allow experiments with radar, F.M., and other high frequency electrical devices. (1)

Another large laboratory and plant is now nearing completion in Syracuse, N.Y., construction of which was announced in 1945. This plant will provide laboratories for research in the electronic field, especially television, radar, frequency modulation and wire recording. The new plant and laboratories have cost of $10,000,000 and occupy some 155 acres laid out and landscaped like a college campus, perhaps to instil the research workers with an atmosphere of university life. (2)

General Electric has a tradition for carrying on research and as the above instances indicate, the research of the future will be continued apace. Among the more important past contributions of the laboratories are found such things as ductile tungsten used as the filament for incandescent lamps, gas filled incandescent lamps in place of the less efficient vacuum bulbs, high power X-ray tubes and high capacity electronic tubes - the heart of radio broadcasting and receiving equipment. (3)

During the war the research activities were centered on the development of intricate and technical equipment to aid in carrying on the war. Of special importance was the work done in radar, radio communications,

(1) Science News Letter, June 16, 1945.
(2) Ibid, Oct. 6, 1945; and personal interview with employee of G.E. Electronic Division.
(3) Forty Ninth Annual, Report, General Electric Company, 1940

F.M. and other signaling equipment, and jet propulsion; other developments were superchargers for planes, electrically heated flying suits for aviators.

2. Research Laboratories Division of General Motors

As another example of continuing research is the work done in the General Motors Laboratories.

In this research division are employed some 500 workers and the budget for the division is close to $2,000,000 annually. This research center has nothing to do with the engineering of the products of the company but serves only as a means of broadening the base from which the company can take over and adapt the product to commercial use. Work is done only in an attempt to find new industries to add to and supplement the line of the parent corporation.

The set up of the research laboratories is on the following basis: First there is a department of chemistry that probes all the specific problems that have to do with chemistry in the industry dealing with such things as paints, varnishes, fuels and metallurgy. This department is further divided into fuel research, rubber research, plating and materials testing sections.

Second there is a department of physics having all the equipment found in a physics laboratory but further subdivided into X-ray, high voltage, ignition and spectroscope divisions.

Then there is the department of design where new apparatus is designed, built and tested. After the fundamental principle has been demonstrated here, a manufacturing division takes over and the design department only enters the picture as consultants.

As a means of selecting the subjects of investigation of the research laboratories is a committee of three to five executives of the laboratories who make their selection on the basis of what are the most important problems facing the industry. (1)

D. New Research Projects

1. Commercial Solvents Corporation will soon break ground for a two million dollar expansion of its research and development department in Terre Haute, Indiana. This program will more than double the size of the company's present research building. The corporation also has plans made for a new bacteriological pilot plant, a separate building for a high pressure research pilot plant, and an addition to the pharmacological laboratory. (2)

2. A new research center has recently been set up by the International Harvester Company for carrying on manufacturing research. The new center will carry on research in three broad areas: technical research or engin-

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(1) Testimony -,Charles Kettering, G.M. Research Division, T.N.E.C. Pt. 30, P 16294-16299, also National Research Council Bulletin #60, Industrial Research Laboratories.
(2) Business Week, February 21, 1948.

eering science, operations, research and training. Eight laboratories are used to house the equipment and personnel of the center.

Centralization of research at Harvester was done for several reasons, the most important of which were: first, that the leading research men of the company were thus brought together from the various plants to a common ground allowing them a greater ease in the exchange of ideas. Second, the principal processing operations of all the company's plants can now be standardized according to the methods found to be best at the central research bureau.

In the past, experience had shown the company that each separate factory excelled in the type of work that the engineer of the plant was best equipped to do. It was felt that by joining the research men and engineers in one central plant, that with conscientious distribution of research results to all separate plant managers, better and more uniform manufacturing would result. (1)

3. Some six months ago the Johns Manville Company opened the first of six buildings which will make up a new research center for the company in New Jersey. This first building is a unique combination of laboratories and pilot plants for use in experimental production. On one side are the laboratories where tests on thermal conductivity are made. Across the corridor is the pilot plant where work

(1) Business Week, January 25, 1947.

is carried on in industrial insulation.

The design of the new building is such as to allow for much flexibility. The laboratories have removable partitions as walls, which can easily and quickly be shifted when more or less space is needed for the work. The rear wall of the plant area also makes use of movable sections to permit the building of additions to the plant or to house extra long equipment. (1)

E. Statement by Dr. Sumner Slichter

In a speech before a meeting of the American Management Association, Dr. Slichter bore out certain of the data presented in this chapter. In brief he said that the expectation is for continuing technological changes and for these changes to be more rapid during the next forty years than before. In the matter of expenditures for industrial research, Dr. Slichter stated that during the period between 1920 and 1940, these amounts increased ninefold and that expenditures made in 1946 were twice those of 1940. (2)

As this chapter has indicated, large scale industrial research facilities are being increased and also the scope of their coverage is being broadened, both factors pointing to the importance of this type of research on the technological development in various fields. However, there is another type of research which is of comparable importance.

(1) Business Week, November 8, 1947
(2) New York Times, January 16, 1948

This is pure or university research as carried on in college and university laboratories or under the supervision of the institutions. This important class of research is dealt with in the next chapter.

Chapter IV

TECHNOLOGICAL DEVELOPMENT AND PURE (UNIVERSITY) RESEARCH

A. In order to aid men to get back to peacetime research and to teaching at war's end, the Research Corporation of New York (which develops inventions assigned to it by public spirited inventors) made available $2,500,000 to be used as grants for educational benefits.

This program was comprised of from one hundred to two hundred grants of $2,500 to $5,000 a year in order that talented scientists who spent the war years in applied research for the armed forces and industry, could undertake research in the universities in pure science, especially chemistry, physics, mathematics and engineering.

During the late war, the government supported a vast research and development program under the Office of Scientific Research and Development (O.S.R.D.), the National Defense Research Council, and various research programs of the Army, Navy and Airforce. Into these areas were drawn most of the nation's competent research men.

By means of the grants above cited, the Research Corporation planned to hasten the return of these men to the important work of pure research and to aid the universities in rebuilding their depleted research faculties and facilities. With this assistance the colleges have been able to build up research-minded staffs who are engaging in the much needed basic research and who are also giving the

necessary training to the large numbers of students who have been attending the universities. (1)

While the war was in progress and after it ended the point was often made that little new basic knowledge came out of the conflict, but rather that the many new items which appeared were the results of previous research and of intensified research on problems already being grappled with during peacetime. A further factor is that since little or no pure or basic research was done during the war and since fewer men were trained for this work, we have lost many years in the attaining of new techniques and improved living standards. With this in mind, such research programs as here described are seen as quite important for our present well being and future progress.

B.. Another instance of the importance given to university work in research is illustrated by the happenings at Lehigh University. Industry has begun to appreciate the service that university laboratories can provide. This is shown by the fact that at Lehigh there has been a 500% increase in research contracts for their chemistry department since 1940.

A university spokesman stated that industry has increasingly realized that certain types of research can

(1) Science Newsletter; October 20,1945

be conducted more effectively in university laboratories which are isolated from the pressure of production. In the university research laboratories, the professor engaged in this work will also transmit to his students a personal enthusiasm for the work which will stand them and industry in good stead when these men enter industrial research laboratories.

The following are illustrative of new projects accepted by Lehigh's department of chemistry. Among these projects is one for Armstrong Cork Company in analytical and leather technology research; for the Bethlehem Steel Corporation work is being done in physical chemistry and chemical engineering; and for the Catalin Corporation of America studies are being conducted in the field of synthetic resins.

Other recent projects were assigned by the Koppers Corporation for studies in the applications of coal tar derivatives, and by the Wm. S. Merrill Company, a manufacturer of pharmaceuticals, which is supporting research in organic chemistry.

Among continuing research projects are those of the Raybestos-Manhattan Company, for which work is devoted to plastics materials, and of the National Oil Products Company which company has also maintained a contract for studies in its field since before the war. (1)

(1) Scientific American, February 1945.

C. As a further indication of the importance being put on university research is the sponsorship by the DuPont Company of eighty-one postgraduate and post-doctoral fellowships awards for 1948 and 1949 with forty-seven universities taking part.

Under this extensive program there are offered for the first time fellowships in electrical engineering at the Massachusetts Institute of Technology and at the University of Illinois; metallurgy at Lehigh University; chemistry at the Carnegie Institute of Technology, the University of Delaware and Washington University.

The actual selection of candidates and the choice of their problems are left to the universities. For the first year forty-five postgraduates are to be in the field of chemistry, fifteen chosen for chemical engineering, seven in mechanical engineering, five in physics, two in electrical engineering and one in metallurgy. Also planned are six postdoctoral fellowships in chemistry. (1

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(1) Business Week, December 20, 1947

Chapter V

TECHNOLOGICAL DEVELOPMENT AND INDIVIDUAL RESEARCH

A. To round out the research picture which so far has been represented by large scale research and by university research, this chapter will deal with research as done by the individual. As an indication of the problems besetting the individual engaged in research, excerpts are here given from a speech made some three years ago by Charles Kettering, Director of the General Motors Research Laboratories.

The individual inventor and research worker is today faced with a multitude of problems in his work. A greater complexity of ideas and methods prevail compared to those facing Goodyear, Bell, Edison, the Wright Brothers and the others of the inventors famous in history. All these men had their troubles-lack of experience, financial problems, lack of facilities and a lack of sympathy and understanding by their fellow men. The individual inventor today has these problems also, but he has some others , too, which make his task the more trying. These will be discussed a little later.

As this country advanced in technology, there also occurred a gradual change in the method of research and invention. Gradually the lone workers, suffering hardships and making sacrifices in the proverbial attic, became fewer in number. One reason for this was expressed by

Edison who said that in his investigations he found that when he uncovered one fact in any new field, it was just as if he had opened but one of a great number of doors, all crying to be opened and to be investigated.

All these unopened doors which Edison faced in the many fields to which his work took him, impressed upon Edison the limitations of individual research. One man could not hope to explore all these beckoning doors in a lifetime. So as a solution to this dilemna, Edison hit on the idea of hiring assistants skilled in each line of endeavor to delve into these many fields for which Edison himself had no time to investigate. Being one of the first to follow such a plan of cooperative research, Edison may be said to be the link between the old school of individual research and the later school of group research.

To give an indication of the multitude of problems that would confront the individual inventor today, the following example is given of the development of the independent wheel suspension mechanism for cars. Let us trace the development through all the steps leading to its final adoption for commercial use.

The individual research worker having conceived the idea of this new system of wheel suspension would first have to do all the paper work involved. To do this work would mean that he would have to be an expert mathematician

to be able to calculate such things as spring tensions and wheel alignments. Also the worker would have to be an expert of steering geometry and to have ability to lay out his idea in the form of a design by use of a drafting table.

Next would come the task of building a completely accurate model. In order to be able to do this the worker would have to be an expert tool and die maker, and he would have to have a well equipped machine shop at hand. Lacking these skills and equipment the cost to have the work done would be several thousand dollars. In any case, the model would be built and tested and as is usually the case there would be many troubles found in its operation and to correct them it would be necessary to go through the whole procedure again and again until finally a successful test would be the result.

At this stage the worker may have the thought that someone else has already thought of this device and has patented it. So a patent search is made costing more time and money. When the field is found clear, drawings of the device are made and a lawyer is engaged to draw up a patent application for submission to the patent office.

To get this far in developing the new idea, a model has been made and a patent applied for and the time elapsed is a year or more. Of course in this period there has been no income for the inventor from his device. However, assuming he is able to go on, the time has now

come to make a working sample of his device. A car is selected and the conversion of the spring suspension system is made. Since his machine shop is inadequate for the larger work now required to be done, the forgings and castings must be contracted out. Months pass and he is finally ready to road test the car with his new device installed. But as usually is the case, the working model doesn't function as the sample did. A spring breaks, wheels shimmy or steering is difficult. Any or all of these problems must be solved and for the inventor to do this he must be a metallurgist, a mechanical engineer, a mathematician, an optimist and also a very well to do man.

If it is assumed that the worker is all these, he is finally at the point where he can demonstrate his device to an automobile company. The new knee action equipped car is put through all its paces before the company engineers. Then follow questions: how many thousands of miles of testing have been done; what is the action of the device in mud or water; what is the effect of freezing slush; and so on?

If it is found that an idea such as this has real merit, a company will subject it to numerous tests which will indicate changes in design to be followed by further tests continuing until final acceptance or re-

jection of the invention. (1)

The end result of this complex and extremely expensive procedure needed to develop, perfect, and have adopted a new invention will be that usually an individual research worker will be able to carry his idea through only one or two stages of development due to the costs. Then he must either abandon it or turn it over to some larger unit better able to develop and exploit the invention than he could. Thus though individual research and invention cannot be said to be extinct, somewhere during the process of development other interests must be given a share in the work in order to procure the necessary financial boost to carry the idea to fruition.

In this chapter and in the preceding two, the various forms of research have been considered. The end results of such past and present research are many and varied. To illustrate one kind of result growing out of research, the next chapter will present a few of the industries which these types of research have helped foster.

(1) Scientific American, January 1945.

Chapter VI

INDUSTRIES GROWING OUT OF TOTAL RESEARCH

A. Prospective New Industries

1. At present certain fields under varying degrees of control give promise of development and an increased well being for the country. As the first of these newly explored fields comes that of photosynthesis. Power is primary to all productive operations. The story of technological progress is in no small part the history of the discovery and use of new forms of power. Man progressed in the use of power from the use of his own brute strength to the use of the lever, pulley, treadmill, mills run by wind and water, up to the present use of steam, electricity and natural gas. These developments are but puny achievements when viewed in light of the promise held forth in the harnessing of solar energy. The green plant is the principal converter of solar energy into material useful to mankind. The process by which plants do this is called photosynthesis.

A first successful step has been made in the harnessing of green chlorophyll of leaves in the work done by Dr. Eyster of Antioch College, Ohio. These new experiments may seem a far cry from the work done by the leaf organism itself, but they are the beginnings of far reaching opportunities.

In the work at Antioch, chlorophyll dissolved in acetone has been made to hang on to bits of talc. The same amount of sunlight is absorbed by this material as would be taken in by plants. If this new technique can be expanded to a larger scale, an entirely new horizon is presented to the world. Man would be enabled to store solar energy and would no longer have to depend on the dwindling supplies of coal and oil which represent stored solar energy acquired over eons of time. (1)

Another study concerned with chlorophyll is being conducted at the University of California. Using radioactive carbon, a by product of atomic fission, science has shown that the work of chlorophyll is done in two stages, one of which can be carried on in the dark, thus indicating the stored solar strength is used to carry out the process during periods when sunlight is lacking. (2)

The person who has been most responsible for the interest being shown in photosynthesis is Dr. Kettering, as already noted, the head of research for General Motors. For the past ten years Dr. Kettering has used his own funds to support the work at Antioch College and to him this interest has been a hobby outside his daily work in

(1) Science Newsletter, January 4, 1947
(2) Science, July 5, 1947

General Motors research. In the words of Dr. Kettering at the meeting of the nation's scientists in Boston between Christmas and the 1948 New Year: "Life is dependent on the ability of nature to use sun energy to convert soda water (CO2H water) through the medium of chlorophyll in foods, fibers and farm goods we need." (1)

2. Chemical Therapy as a second field of development is a direct outgrowth of research in another monopoly industry, the chemical and dye works - especially that of the I. G. Farbenworks. From research in this industry came the discovery of the sulfanilimide compounds. German, French, British and American institutions played an important part in the subsequent development of this oft called "wonder drug".

About 20,000 substances related to sulfanilimide have already been made and the task of trying all these on diseases for which they may be helpful has been begun. Chemical cures have made remarkable headway and in the use of vitamins and hormones therapeutically much headway has been made. Among the more important discoveries beyond sulfanilamide have been those of penicillin, chlomycetin and streptomycin.

Recently a new use has been found for penicillin having to do with dental caries. A group of some two hundred fifty boys took part in an experiment, part

(1) Newsweek, January 6, 1947.

of the group using a toothpowder containing the drug and the remainder using ordinary means. At the end of five months, the two groups were tested and the boys who had used the chemical during this time were found to have a 65% lower bacillus count in their mouths compared to a 43% lower count for part of the other group and a 20% higher count for the remainder. A similar experiment with rats who were exposed to the penicillin in their drinking water showed these animals to have fewer cavities than the control group of rats. (1)

In fighting tuberculosis man has found a staunch ally in another of the still young chemicals used in disease treatment. Fresh evidence taken from the bodies of patients who have died from T.B. shows the power of this drug, streptomycin. At the Mayo Clinic microscopic examination was made of T.B. infected brain, lung, liver and spleen tissues. From this investigation it was found there had been a healing of tuberculous spots in these organs due to the action of the chemical agent. In other cases of living patients, widespread development of the disease was prevented and a cure was made in two other cases. Thus there is a strong hope for an eventual cure of this meningeal type of T.B. which hithertofore has always been fatal. (2)

(1) Science Newsletter, June 21, 1947
(2) Science Newsletter, August 16, 1947

As a weapon to fight the plague too, streptomycin has shown its worth. Five patients with temperatures as high as 106.6° were dying of plague in India. Sulfa drugs had been given to three of the men to no avail. However, upon treatment with streptomycin improvement was noted within 36 hours and the patients were saved. (1)

Belonging to the penicillin - streptomycin group is another new remedy being used in chemical therapy. This discovery made by Dr. Burkholder of Yale in the latter part of 1947 is called chloromycetin and in laboratory tests has proved to be effective against typhus fever, Rocky Mountain spotted fever, and parrot fever. Large doses given animals were not harmful and administration was by mouth or hypodermic needle. However, before the chemical can be administered to human beings, further lengthy and careful tests must be made as to the toxity of the chemical. (2)

These antibiotics here described are not limited to use on man but can be put to good use against plant diseases also, and it has been found in tests at the University of Wisconsin that apple scab and early tomato blight can be completely controlled. (3)

Discoveries in this new field of chemical therapy are continuing and the latest report is of a new

(1) Science Newsletter, January 31, 1948
(2) Science, October 31, 1947
(3) Science Newsletter, January 17, 1948

agent called decapryn which completely relieves most hay fever victims and patients with hives. (1) It is thus seen that this new field is a fast expanding one and will be of the most importance in man's fight against diseases.

3. A third field of new industry is that of synthetic materials, many of which had their beginnings in research laboratories of such concentrated industries as DuPont and American Viscose Corporation. Notable among these materials are nylon, rayon vinyon, synthetic wool, and glass fibers. Many valuable uses have been found for these new products; witness the value found in the resiliency of a nylon line in picking up materials or human beings from the ground by means of a nylon line attached to a speeding airplane, or for parachutes during war time. In the case of rayon, its greater use to the exclusion of cotton in automobile tires is due to the greater strength and cooler running temperature of rayon. Glass fibers have not been as prominent in use; nevertheless it has been shown that clothing can be made from these fibers and samples have been made of entire wardrobes for women made of glass.

The rayon industry is being pressed to the limit to meet demands upon it. Tiremakers alone are absorbing over 75% of the current output and are demand-

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(1) Science Newsletter, February 7, 1948

ing more for the reasons above mentioned. The present output of rayon is a billion pounds a year, but even at this figure demand is so keen that German exports are finding a good market in this country. (1)

Attempts to boost output to meet demand are being made but the hurdle of the high plant cost is holding back expansion. A new means of producing the yarn on a continuous basis in a simplified manner has been begun by one company, (2), which, however, has reported that the cost of the equipment installed was too high to justify increasing capacity. (3) Until a new and cheaper means of production can be devised, construction costs can be lowered, or a higher competitive price allowed, it is apparent the output of the industry will remain close to its present levels with imports filling the need.

As further progress is made in atomic research and photosynthesis, it may become a crime to use coal or oil as a fuel because their chemical constituents are much more valuable than their energy content. In recent years coal and oil have come to be considered as sources of chemical compounds which can be torn down and then built up again into other compounds of more useful commercial value. The use of coal as a building block for chemical compounds has just begun.

(1) Business Week, November 8, 1947
(2) Business Week, January 27, 1940
(3) Business Week, November 15, 1947

For an example of this type of chemical by-play, a few words about oil from shale. In the United States there are some 92 billion barrels of oil contained in imbedded oil shales. Gasoline from oil shales has been produced for several years in various countries with production in this country delayed because of apparent abundant natural supplies.

At present a pilot plant in Colorado is producing a dribble of 2000 gallons a day, but a step up is expected. The extraction of oil from shale is a simple process, costly only in the procuring and transporting and crushing of the shale. Other steps in oil production are from coal and lignite. (1)

4. A final field for progress is that of cataloging or mobilizing scientific knowledge. Of impedance to such a dissemination of human knowledge have been various monopolistic interests and patent laws both tending to control certain knowledge within their spheres of influence. With the increasing pace of research, invention and discovery, the distribution of these findings has become an increasingly important problem.

Scientific discoveries are normally made public when not suppressed for monopoly purposes, by means of publication in scientific papers, the issuance of patents

(1) Science Newsletter, May 24, 1947

on the findings, or at scientific meetings and conferences. Thus, over the years, a hodgepodge of past research has been built up and the journals, books and reports have been accumulated in libraries.

The data and knowledge are adequately reported except where suppression takes place as indicated above, and to overcome this condition new mechanisms must be found to allow knowledge to be commonly available. Even knowledge which is on file on each subject is relatively poorly organized so that one cannot put his finger on all the literature on one subject with either completeness, or ease, or at reasonable cost. In many fields bibliographic resources are quite inadequate with a result that researchers are not able to discover what findings have been made by a particular inquiry in the past. Since all progress is dependent on past activities, our inability to locate specific findings or at best to find only incomplete data, means that progress is to that degree hindered. In carrying out research the scientist may omit some past pertinent information, or, due to a lack of knowledge, he may go over the same ground which another had traveled before with a resultant duplication of effort and loss of valuable time.

Basic to a marshaling of technical knowledge has been the card index. Of a similar and developing usefulness is microfilm which allows reduced size photographic images of any matter which can be reached by a

camera lens.

By means of microfilm scientific workers are afforded the means of studying copies of articles and papers from library archives without the necessity of traveling to the library. This is especially of advantage where but a single copy of the original work is available or where it would not be economically practical to print and widely distribute a research report.

Of the major commercial microfilm concerns doing this very work now are J. W. Edwards Co., University Microfilms and the Recordak Corporation. Edwards has an extensive publication program in progress reproducing material full size or miniature with the largest single work completed being the 167 volume "Catalog of Books Represented by Library of Congress Cards." Also reproduced have been the British Museum Catalogue, 3200 issues of journals and some 700 separate books.

The second firm, University Microfilms of Ann Arbor, Michigan has under way, in addition to other work, a project begun 10 years ago, of microcopying English books published before 1600. Already they have completed and sent out to subscribers over a million pages. Then, too, 70,000 pages of American periodicals (1741-1800) have been copied and material from 1800-25 is now in process. Copying was also done of 14000 wartime serials

and arrangements have been made to film dissertations presented at twelve universities. Overseas work also is continuing apace with cameras at work in Cambridge, Oxford, Holland, Belgium, France, Switzerland and the Vatican.

Recordak, the third firm, has been especially concerned with the microfilming of newspaper files. Arrangements have been made for the current copying of leading papers throughout the country in addition to a great deal of work with the thousands of back copies of newspapers resting in libraries and taking immense amounts of space. Work by this company has been done at the Boston Public Library where eight Recordak machines are available for viewing microfilmed materials of various types. This field as a whole gives the impression of great activity with much experimentation and research under way. (1)

With mechanical and microfilm devices becoming well established and perfected, the marshaling of scientific and technical knowledge so that it can be used to its fullest extent, can indeed be a project the benefits of which would be immense and would be a basis of what H. G. Wells has called a "World Brain". (2)

(1) Library Journal, December 1, 1947
(2) H.G. Wells, "World Brain".

A great part of scientific writing has been compiled by title or synopsis of bibliography in abstract journals or large card compilations. Microfilming as begun will allow expansion of these card compilations by breaking down their information into various subject classifications. This information can then be copied on film for distribution to scientists and inventors as needed by them.

Such a project would be costly both in time and money and would require world wide cooperation, but the returns to industry and mankind through a speeding of research and invention would make the undertaking of the problem more than worthwhile.

B. Specific New Industries

In the preceding section various industries, discoveries, and projects were treated, not all as factors which will influence humanity in the immediate future, but rather matters to be considered as possibly being developed within following decades. In contrast, in this section, certain specific industries will be treated in light of the present or near future effect they may be expected to have upon mankind.

1. First on the list of specific industries is that of atomic energy. For the most part the research in this realm has been well shrouded in secrecy and even now little is known except for the magnitude of the undertaking in money, materials and men. From the findings of

of atomic research, many benefits have been promised the public. An example of a first use of the by-products of the atom bomb is that being developed by a new company called Tracerlab, Inc. of Boston.

This company was started less than two years ago as a child of the atom bomb out of radar. The basis of the business is radioactive isotopic tracers and the instruments needed to trace them. These isotopes are unstable outgrowths of basic elements. During their short period of life these isotopes emit radiations and when introduced into the human body, their progress through the body can be traced by means of their radiations. Through them diseases can be studied, the actions of drugs can be followed, and eventually as a means of probing the life cycle itself. In industrial processes, too, these isotopes have immense possibilities, the surface of which have yet but been scratched.

Tracerlab, although an outgrowth of two highly guarded monopolies, atomic energy and radar, indicates that research, whether done under free or controlled conditions, will bring forth some findings even though they may be incidental to the primary project, which can be used for the betterment of mankind. From its small beginnings in 1946, this company has already reached a sales rate of $300,000 a year and counts as customers for its

radioisotopes the United States Atomic Energy Commission, many universities, hospitals and private industrial laboratories, in addition to some twelve foreign countries. (1)

2. A second industry to be treated is the prefabricated housing industry where monopoly control by means of the trade union has been a large factor in the slowness of growth compared to what had been expected. In another sense too, monopoly prevails here in that the product, the house, itself, is unique. There is no real substitute for the individual house and so the industry of itself is a great monopoly even though the intent may not be to this end. The builder has nothing in common with the wheat grower as the example of greatest competition where the commodity supplied is completely homogeneous; or with the automobile manufacturer, who though in monopolistic competition, must constantly add gadgets, present new styles, and forecast public demands. In contrast the house is an individual product as ordered by a buyer or to the demand of a limited group of people. Despite the apparent slowness in house building, actually much progress has been made already when it is realized that not many years ago all the fabrication was done on or close to the job by the carpenter, plumber, or electrician, whereas today there are a great many parts of the house which have been adapted to prefabrication on a mass production basis. For example, doors

(1) Fortune, "Business in Isotopes", December 1947

and windows of stock sizes are made in the factory; furnace units are assembled as a packaged heating plant; and kitchens and bathrooms are made in the factory as units complete except for comparatively simple installation.

Various forms of resistance have been met in developing the new prefabricated housing industry. The general public for one has been slow in its acceptance of this type of housing. Other factors to be considered are the lack of cooperation on the part of labor, inflexible requirements of building codes, and transporation difficulties in shipping unwieldy items, both in the matter of handling and cost.

In the field of prefabricated houses are several companies operating with varying success. One of these companies is located in the outskirts of Baltimore (The Byrne Organization of Washington, D.C.) where their mobile factory is turning out finished houses at the rate of ten to fifteen a day. The houses are of a basic pattern with 962 square feet of floor space, three bedrooms, radiant heating, and constructed of a welded steel framework, with a stucco or aluminum clapboard exterior and sell at $6950, a price some $1000 lower than that charged for comparable non mass produced houses in the area.

The basic shop or factory for producing these prefabricated houses consists of nine large Quonset huts

housing all the material and machines needed. This plant is highly mobile and as contracts are gotten, the whole factory unit can be moved on to another site adjacent to the new housing site. By having the factory where the houses are assembled; i.e. where the houses are to be built, the problem previously mentioned of transporting large cumbersome parts is solved. Use can also be made of materials which would in ordinary building be discarded. In the shops the whole radiant heating system, plumbing assembly, walls, partitions and complete roof (in one piece) and chimney are fabricated from their component parts necessitating only relatively simple assembly on the house lot. It is estimated that this company must have an order for at least 300 units at each site to operate profitably. (1)

Another company operating in a somewhat different manner is the firm of Levitt and Sons of Manhasset, New York. This company is the largest private house builder in the east, having turned out some 3000 houses in 1947. These houses, too, are all of the same basic pattern with radiant heating, two bedrooms, and of wooden construction at a cost of $6990, or some two thousand less than non mass produced houses.

In contrast to the Byrne Company, the Levitt concern precuts materials at its central factory and then

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(1) Fortune, August 1947.

ships by rail to the vicinity of the housing site where trucks pick up the materials. In front of each house foundation is dropped all the parts needed for the building and assembly is mostly fitting and nailing of the parts. (1)

To accomplish building operations as above described, investment on a large scale is necessary, for the most part beyond that which private industry can or will put up. Only one firm, the Lustron Corp., has appeared in the field to fill the gap. This company would use automobile assembly line methods to produce low cost, long life housing. Capitalization of the firm was set at $16,340,000 with much aid from the government in the form of an RFC loan for $15½ million. The completed houses will be 32 feet X 35½ feet and will sell for $7,000. (2)

From these facts it can be seen that the problems retarding the development of the prefab industry can be overcome where there is local acceptance by the community and a relaxation of the restraining effects of certain labor rules which have worked to the detriment of housing in general.

(1) Fortune, August 1947
(2) New York Times, November 1, 1947

Chapter VII

ABUSES OF MONOPOLY

A. In the preceding chapters we have seen how various types of research have worked toward the progress of the country and how research has been developing various new industries. In this chapter the emphasis will be on the less acceptable side of monopolies as shown by their perverting research facilities so as to impair the quality and to contaminate products as means of ensuring control of the market and of the price. The material for this chapter was drawn from a report of a Senate investigation of Monopolies and Cartels made in 1944.

1. As an example of the technique of impairment of quality the following is presented. Under international cartel agreements and control of patents, the American market for electric light bulbs has been reserved for General Electric and Westinghouse. Thus, protected from foreign and domestic competition, these firms set their research facilities to work in reverse; that is, instead of attempting to find means of increasing the life of bulbs, ways to decrease their life were sought. The excuse found for reducing the durability of light bulbs was in fact that the efficiency of a light bulb is inverse ratio to its length of life. Care was taken not to

inform consumers of their decision to sacrifice durability, nor to allow an opportunity for buyers to choose other bulbs which might be more durable by forcing patent licensees to follow the policy set by General Electric and Westinghouse. Excerpts of a letter written in 1937 by a General Electric official to an official of the Champion Light Works makes this factor clear:

> "Decision has just been made to change the life of the 200 watt 110-120 volt Ps30 bulb lamp from 1000 hours design and published to 750 hours design and published. This change will be made on clear, white bowl and inside frost finish lamps, but the silver bowl and the daylight lamps will be continued at 1000 hours design and published.
>
> We do not know just when the change will go into effect, and we are giving no publicity whatever to the fact that the change is contemplated. I am giving you this information today, just as we are giving it to our own factories, so that you, too, can start building up some 750-hour stock in contemplation of the untimate change".

Another letter of similar nature follows, written in 1939 by a General Electric official to an official of Tung-Sol Lamp works:

> "The design life of the 2330 Lamp has been changed from 300 back to 200 hours, the change to take effect as soon as manufacturing facilities will permit. It is understood that no publicity or other announcement will be made of the change."

The information in these two letters serves to indicate the ease with which monopolistic industries can act in such a matter as a change in the quality of their product. Since they control the product of other companies licensed by them, there can be no problem of one company producing a better quality article than the others.

2. The second unwholesome activity of the monopoly interests to be brought out has to do with the use of research facilities to contaminate a product. One purpose for which quality may be deliberately reduced is to prevent a commodity sold at a low price from being substituted for another which the same seller is able to sell at a higher price.

Such a situation of a price disparity between products existed among certain dental plastics made by DuPont and Rohm and Haas Company. These two companies controlled the supply and fixed the price of methyl methacrylate powders which were used by commercial firms as part of their manufacturing process and by dentists and dental laboratories in making artificial dentures. The price charged to the commercial users was .85 cents a pound while the price for the exact same product to dentists was $45 a pound. In 1941 DuPont had a total investment of $986,000 in its plant making this chemical compound, and in the first six months of the year, the net profits were $210,000.

About this time certain dental purchasers discovered that they could obtain the same powders for dentures at incredibly low prices by buying it as a commercial molding powder. This the producers called "bootlegging". As a consequence, the producers set their research facilities to work to develop some means to prevent such purchases. A quote from a letter written to

Rohm & Haas Company shows the extremes to which the company was willing to go to keep dental interests from buying the commercial powder.

> "Our discussion of the Pure Food and Drug Law and pulling the acrylic denture under it leads me to wonder if the manufacturers of the commercial molding powders might not add an ingredient which would not affect the molding properties, but which would disqualify it under the act........
>
> Recently I asked Dr. Johnson to suggest an addition. Under the very finicky regulations of the above act, however, it may be the slightest trace of the right agent, too little to constitute harm to molding (or health, either, as a matter of fact) would suffice to have bootleg products in bad.
>
> A millionth of one per cent of arsenic or lead might cause them to confiscate every bootleg unit in the country. There ought to be a trace of something that would make them rear up."

To this letter, Röhm & Haas replied:

> "We agree with you that if we could put some ingredient in our commercial molding material which would disqualify it under the Pure Food and Drug Act, this would be a very fine method of controlling the bootleg situation. We shall take this matter up with our development department and advise you whether any such material could be used."

Another example of the way in which research facilities of monopolies are employed in order to preserve the monopoly power is seen in the actions of DuPont in the field of chemistry. DuPont had developed a pigment which could be used either as a paint or as a textile dye, but feared that the latter use would upset the structure of textile dyestuff prices. As a result of this situation the DuPont laboratories were set to work to find some contaminants which would make the colors unsatisfactory

for textiles but satisfactory for paints. In June 1940 the matter was thoroughly discussed in a conference with representatives of General Aniline Works. The resourcefulness with which research in methods of aduleration had been carried on is apparent from a reading of the recommendations of the laboratories which follow:

(a) Mixture of a special chemical with the various colored pigments, which mixture would have good fastness of color under light, and yet be poor in wash fastness on textiles.

(b) Deteriorate cotton - compounds of the special chemical which when applied to textiles and followed by heating or bleaching would cause increased cloth deterioration.

(c) Irritating substances - compounds of resins and solvents which are irritating to the skin would be applied to the textiles to cause dermatitis.

(d) Incorporation of grit - this to make the use of the textiles after dyeing quite useless.

B. Further illustrations on this subject of the abuses of monopolies in the matter of research could be cited; however, the ones herein described are representative and it is suggested that anyone who would care to delve further into this aspect, to consult the Senate Committee report on which this chapter is based. (1)

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(1) Economic and Political Aspects of International Cartels, Monograph #1, 78th Congress, 2nd Session, Washington 1944. Pages 13, 15, 16, 17, 18, 19, 36, 37.

CONCLUSIONS

The conclusions reached as a result of this study are as follows:

Complete freedom of technological development would in itself perhaps do more harm to the economy than complete monopoly control of development. Too rapid progress could be an evil of greater proportions than too slow progress. Under conditions of rapid industrial change where new methods, techniques and machines are being perfected at a rate which is too accelerated for industry to make efficient use of these developments, perhaps here monopolies would be found to be a valuable asset by their exerting a necessary restraining influence to temper the too rapid changes being contemplated. Without the guiding hand of monopoly interests at such a time, irreparable damage might be done to the economy.

On the other side, however, if monopolies act to retard progress to too great an extent, such a situation would often be adverse to the public good. Where progress is made secondary to present gain from existing processes and plants, the role of monopoly control must be considered a distinct hindrance to the country's growth.

It is hard to make any generalizations as to which is the better answer to the problem. Things as they happen may have to be judged as individual cases against

the background of the times. The answers to the problem which would prevail at this time would be of much lesser value in solving the problem a few years hence. Perhaps in viewing the overall picture, it can be said that the economy should be set to follow a middle course with the gyrations of progress under the competitive situation, tempered by monopoly interests, but only to such a degree that the rate of technological development is matched with the pace of the times. However, this control should not be of such a nature that there would result a great time lag between the discovery and application of new techniques.

In the matter of research, of the three types of research discussed; that is, large scale, university and individual, the first two are by far the most important. Of these two, large scale industrial research is the greater in amount of money spent. Most of the industrial laboratories are used to deal with specific problems of the industry while much research done in the university laboratory can be classed as pure research. Of course this is not a completely true statement for either case as industrial laboratories do carry on pure research, and as indicated in the chapter on university research, in addition to pure research, very specific work is done here on various industry projects. However, as a general statement it may be said that large scale research work is aimed

at solving specific industry problems, while university work is mainly to probe further into the unknown in an attempt to add to man's knowledge in all fields.

As to individual research, in times gone by this type of work was all important and as we look back through the centuries the names of famous men stand out as individual contributors in the fields of chemistry, physics, medicine, etc. During this past period research was done by the individual and therefore much of our basis for progress was due to their labors in discovering the truths of nature.

However, under our present day system, research by the individual, though still carried on, can hardly compete with the work of the industrial and university establishments, either in size or accomplishments. Though the idea may be born of the individual, to carry it to fruition today requires facilities beyond those available to the individual.

In the province of new industries growing out of total research, there is but little to add to that which was brought out in the chapter on this topic. The six industries treated were taken as examples of some of the types of industries which can and do result from man's research activities. As research continues more and more techniques will be developed and as these are perfected and

put to use, they will lead to a constant raising of our standard of living. Thus through research and the resultant new industries set up to utilize the new knowledge, man can look to a betterment of his lot in life.

The final part of this work, that dealing with the abuses of monopoly in research, would seem to indicate that some further government regulation needs to be evolved to control the activities to which research may be put and also the use that may be made of all research. The end result of research should be toward a betterment of mankind not to hold or to make more sure the control of monopoly over certain areas of production.

Of course over a long period of time there may occur such a raising of man's ethical standards as new generations of business men with a keener concept of their responsibilities to society reach positions of control in industry. Such a prospect is rather remote at present and therefore it can only be the hope of an idealist, that such a change will occur within the foreseeable future.

As always, it is more difficult for us to solve present problems than it is for a later generation which views them in retrospect. When this era is over, future economists and historians may look back on this and our many other present day problems and point to various solutions which never occurred to us at this time. However, on this final point of the misuse of research by monopolistic

interests, if we discount the thought of control by man himself due to a greater individual concern for the economy of the country, the more valid solution is the former one, of government control of abuses in industrial research.

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